U. S. ARMY TEST AND EVALUATION COMMAND
COMMON ENGINEERING TEST PROCEDURE

MISSILEBORNE SENSING ELEMENTS-INERTIAL

1. OBJECTIVE

The objective of this test is to obtain stable platform data which can be interpreted in terms of missile system performance.

2. BACKGROUND

The master reference for an inertial guidance system is the stable platform which may be classified as a high accuracy type. Low accuracy platform systems commonly are used in missiles that are not truly inertially guided. This type of platform usually is found in a system which comprises a combination of inertial and ground guidance or some form of homing system, and in some attitude measuring telemetry systems. The engineering tests outlined in this materiel test procedure are adequate for and applicable to either type of stable platform. The data obtained from these tests can be used in flight trajectory analyses, in flight simulation studies and in evaluation of missile system performance.

3. REQUIRED EQUIPMENT

a. Monitoring Instrumentations
b. Multiohmeters
c. Wheatstone Bridge
d. 500 Volt (d-c) Meggers
e. Voltage Sources (as required)
f. High Potential Tester
g. Adjustable Gimbal Clamping Devices
h. Punch Stick
i. Torque Generator
j. 2 Axis Dividing Head
k. Holding Fixture
l. Voltmeter
m. Signal Generator
n. Sidereal or Planetary Test Stand
o. 3 Axis Flight Simulating Table of Scorsby Table
p. 3 Channel Voltage Recorder
q. 3 Auto Collimators (Optional)
r. Centrifuge
s. Ammeter

4. REFERENCES

A. AF Manual 52-31, Guided Missile Fundamental, Dept of the Air Force, Washington, D.C., 20 September 1957
B. Lees, Sidney, Air Space and Instruments, McGraw-Hill Book Company, Inc., New York, 1963.
C. Van Nostrand, D., International Dictionary of Physics and Electronics D. Van Nostrand Co. Inc., New York.

D. Roberson, Robert E. And Farrior, James S., Guidance and Control, Progress in Astronautics and Rocketry, Volume 8, Academic Press, New York, 1962.
E. MIL-I-6181D Interference Control Requirements, Aircraft Equipment
F. MTP 5-2-583: Low Temperature Tests
G. MTP 5-2-594: High Temperature Tests
H. MTP 5-2-507: Vibration Test Procedures
I. MTP 5-2-538: Servo Mechanisms

5. SCOPE

5.1 SUMMARY

In general, the tests described in this MTP are designed to yield quantitative data on the platform with the sensing end organs and components. (See Appendix A for a description of stable platforms and their associated sensing devices). Since a composite of various inertial systems will be discussed in this MTP, no attempt will be made to prescribe the mode (normal or laboratory) to which a specific test may be assigned. The following Tests are described:

a. Visual Examination - This test is conducted to determine obvious defects, poor workmanship, damage in shipping, general appearance and conformity to military standards and specifications.

b. Resistance and Insulation - This test gives a quick indication of electrical malfunction or component failures

c. Gimbal Alignment and Construction - Determination of the orthogonality of gimbal alignment and balance

d. Accelerometer Null offset - Determination of accelerometer null offset

e. Accelerometer alignment - This test is conducted to establish accelerometer alignment

f. Accelerometer Scale Factor - The purpose of this test is to determine the accelerometer scale factor up to one g.

g. Erection and Alignment Loops - Tests conducted on an individual merit basis to determine erection and alignment loop characteristics.

h. Platform Drift - Tests conducted to determine platform drift rates

g. Resolver Alignment - The purpose of this test is to determine if the vector sum of the inputs to the resolver is always equal to the output when the platform's space orientation is varied

h. Gimbal Pickoff Alignment and Linearity - These tests determine the alignment of platform gimbal pickoffs with respect to the platform

i. Gimbal Angular Freedom - This test is conducted to determine the maximum displacement of the gimbals in both directions

j. Positioning of the Azimuth Gimbal - The purpose of this test is to ensure that there is proper positioning of the azimuth gimbal by the azimuth signal generator and torque and linearity characteristics of the generator

k. Gyro Precession - This test determines if there is proper gyro precession

l. Platform Caging Provisions - These test are very generally described and discuss testing for adequate locking or caging in a preset orientation

m. Environmental Testing - Tests conducted to determine the effects of various environments

5.2 LIMITATIONS

None

6. PROCEDURES

6.1 PREPARATION FOR TEST

a. Select monitoring instrumentation on the basis of the military characteristics of the guidance system and by the permissible guidance error as determined by means of unit of variance allotment procedures

b. Unless system instrumentation requirements state otherwise, instrumentation requirements shall be a factor of 10 better than the function being measured.

6.2 TEST CONDUCT

NOTE: The following procedures are based upon the assumption that the pitch gyro spin reference axis (SRA) is in the same plane with, although not necessarily precisely parallel to the missile longitudinal axis (MLA). This is not always the case, since sometimes the pitch gyro SRA is perpendicular to the MLA. In such cases, this procedures is 90 degrees out of proper orientation, but the test philosophy still holds true. With appropriate orientation, the test can be conducted.

6.2.1 Visual Examination

Conduct a detailed visual examination on all inertial hardware upon receipt to determine and record the following:

a. Compliance with configuration and workmanship requirements
b. State of preservation
c. Packaging
d. Identification markings

NOTE: Associated drawings and military specification shall be used as guides in conducting examinations

6.2.2 Resistance and Insulation

NOTE: The accuracy of the test instruments used will depend upon the nature of the circuit being tested.

a. Using multiohmeters and wheatstone bridges measure and record point-to-point resistance values at accessible tests points.

NOTE: Connecting plug pins provide convenient points from which measurements can be made.

b. Determine and record the insulation between isolated circuits and the assembly case and between independent circuits using five hundred volt (d-c) meggers.

c. Connect a 1000-volt or higher high potential tester or equivalent between isolated circuits and read and record resistance values.

6.2.3 Gimbal Alignment and Construction

If valid certification for the orthogonality of gimbal alignment and balance has not been accomplished, it shall be ascertained by test methods outlined herein.

a. Preparation

1) Mount the platform in an adequate and accurately machined holding fixture

NOTE: The platform construction shall be such that access to the gimbal is possible

2) Properly orient the platform and affix it to the face plate of a 2-axis dividing head which has been accurately leveled in both planes

NOTE: One of the three gimbals which comprise the subassembles of an inertial platform(usually the inner yaw gimbal) was selected during design as the reference stable element. It is this gimbal upon which are located the various stabilizing gyroscopes, guidance accelerometers and other sensing devices.

3) Select the middle gimbal as the reference gimbal for the orthogonality test. For purposes of this test assume that this is the roll gimbal and the outer gimbal is the pitch gimbal.
4) Using adjustable clamping devices, render all three platform gimbals temporarily immovable and in true alignment with platform frame and monitoring the gimbals output and adjust each for null by means of the adjustable clamp.
5) Connect output of yaw gyro to a voltage recorder.
6) Align the platform roll gimbal axis parallel with the dividing head tilting axis as accurately as can be done by eye.
7) Tilt the dividing head, with the platform mounted thereon, to an angle of 30 degrees. This will be the same as rolling the platform 30 degrees about its roll axis.
8) Record the dividing head angle of tilt (to be used as a zero reference tilt angle in later tests).

NOTE: The pitch and roll gyros and servo systems may have to be disabled to accomplish the following steps:

9) Electrically energize the platform, the controls, monitoring instrumentation and the recorder.

10) After a suitable warm-up time, increase and decrease the 30 degree tilting head by exactly 3 degrees each way while monitoring and recording the yaw gyro output.
11) If there is a gyro output, restore the tilting surface to 30 degrees, then revolve the dividing head a slight amount about its rotating axis s(not the tilting axis).
12) Repeat the plus and minus 3-degree tilting process of step 9 and note if the gyro output has increased or decreased.
13) Repeat steps 10 and 11 until there is no gyro output change for a plus or minus 3-degree change in tilt.
14) For fine accuracy of alignment, repeat steps 8 through 12 except that in this case, the tilt change shall be plus and minus 30 degrees instead of three degrees
15) Accurately read and record the position of the dividing head rotating surface; this position will be used as another zero reference for the rotating surface in tests to follow.

NOTE: There shall be little or no output from the gyro gimbal pickoff since now, parallelism between the gyro SRA and the dividing head tilting axis has been achieved.

b. Test Conduct

1) Reposition the dividing head tilt to the original zero reference of 30 degrees.
2) Remove the clamp from the platform roll gimbal only. Do not disturb the clamping of the other two gimbals.
3) By means of a finger, punch stick or torque generator, rotate the platform roll gimbal about its axis while again monitoring and recording the yaw gyro output.
4) Record any algebraic differences between the yaw gyro output now obtained and that obtained in paragraph 6.2.3.a step 14 (when the roll gimbal was clamped) as an indication of misalignment between the platform roll and pitch gimbals.
5) Re-position and re-clamp the platform roll gimbal as it was in step 4 of paragraph 6.2.3.a.
6) De-energize all gyros.
7) Connect the output of the roll and pitch gyros to voltage recorders.
8) Re-position the tilting surgace to horizontal (zero degree tilt).
9) Rotate the dividing head surface plate 90 degrees plus or minus two seconds, from that zero reference position determined in step 15 paragraph 6.2.3.a.
10) Energize the roll and pitch gyros.
11) Energize monitoring instrumentation.
12) Tilt the dividing head surface plate to the 30-degree tilt. reference position established in step 8 paragraph 6.2.3.a., while monitoring the outputs of the roll and pitch gyros.

NOTE: There should be little or no output from either. Any discernible output represents misalignment of the pitch and roll gyros, either

internal to their own mounting surfaces or their misalignment on the platform with respect to the yaw gyro alignment.

13) Record any voltage output observed from either of the gyros as an indication of misalignment between roll and pitch gyros.
14) Restore the dividing head tilted surface plate to horizontal.
15) Remove the clamp from inner (yaw) gimbal.
16) Rotate the inner gimbal about its axis in the manner described in step 3 for the roll gimbal.
17) Monitor the output of the roll gyro.
18) Record any algebraic differences between the roll gyro output observed and the output recorded in step 13 as an indication of nonorthogonality of the platform inner gimbal with respect to the roll or middle gimbal.
19) De-energize all gyros and rotate the surface plate to the zero reference obtained in paragraph 6.2.3.a step 15.

NOTE: Be sure the tilting surface is horizontal (zero tilt)

20) Energize the yaw gyro in open loop mode (with the gyro gimbal torque servo inoperative).
21) Align and clamp all gimbals and the frame together as in step 4.
22) Monitor and record the output of the yaw, gyro.

NOTE: It should be null or zero

23) Affix another suitable fixture or clamp to the platform outer gimbal so that it cannot rotate about a vertical axis.
24) Remove the original clamp between the outer gimbal and the platform case, thus permitting the case to be turned about the outer gimbal and the two inner gimbals which are clamped to it.
25) While accurately monitoring the output of the pitch gyro, rotate the dividing head surface plate clockwise (CW) and counterclockwise (CCW) 15 degrees in each direction.
26) Observe and record any output voltage of the pitch gyro as an indication of misalignment between the outer gimbal and the platform case of frame.

6.2.4 Accelerometer Null Offset

a. Mount the platform in its precision fixture and it in turn, mounted on a precision dividing head as outlined in paragraph 6.2.3.a.

b. Monitor and record the accelerometer outputs for the lowest readings while adjusting the gimbal clamps and the dividing head positions.

6.2.5 Accelerometer Alignment

Much the same test philosophy and procedure is used as was done in determining gyro alignment in paragraph 6.2.3.a . Experience on the part of the operator will render this test simple.

6.2.6 Accelerometer Scale Factor

After accelerometer alignment and null offset have been obtained, the accelerometer scale factor up to one g will be accomplished by properly orienting and tilting the dividing head through a series of ten angles from zero to 90 degrees while monitoring and recording the accelerometer output and recording the angle.

6.2.7 Erection and Alignment Loops

The testing of erection and alignment loops shall be accomplished in accordance with MTP 5-2-538. Where possible this test shall be conducted by means of signal generator inputs and suitable monitoring instrumentation independently of the sensors or end organs which normally provide the input signals. In addition, this test shall be conducted in closed loop mode in conjunction with sensing organs which provide the inputs in flight and the servo actuated devices which accomplish guidance error correction. Closed loop servo mode testing in some instances will involve exercising the platform by means of a Scorsby Table or a 3- axis flight simulating table.

6.2.8 Platform Drifts

6.2.8.1 Static Drift

Three methods of accomplishing this test are discussed as follows:

a. First method

1) From the designer's or manufacturer's drawing of relative angular orientation determine the arrangement of the gimbaling and sensing organs.

NOTE: It will be found that all three gyros are positioned to sense mutually orthogonal motions, but two of them will have their SRA's parallel to each other. For easy reference, assume that they are the pitch and roll gyros, Designate these gyros as numbers 1 and 2, respectively. The SRA of gyro number 3 which would be the yaw gyro will be at right angles to those of numbers 1 and 2.

2) By means of the gimbal clamping devices, adjust all gimbals to zero output and mount the platform in its fixture on a dividing head so that the SRA's of numbers 1 and 2 gyros are vertical.

3) Adjust the dividing head in tilt until the SRA's of gyros 1 and 2 are positioned at an angle to the local horizontal plane.

NOTE: This will place the SRA's of numbers 1 and 2 gyros parallel with the earths rotational axis, resulting in no effects of the earth's rotation being sensed by the input axes (IA) of these two gyros.

In the northern hemisphere, the north end of the gyro's SRA would appear to be tilted up; in the southern hemisphere, the north end of the axis would appear to be tilted down, relative to the local horizontal plane. The SRA of gyro number 3 will now be directed true east and west. It's IA will sense the full component of earth's rotational effect, which is 15.04 degrees per hour.

4) Connect monitoring instrumentation.
5) Disable any accelerometer feedback loops to gyros if necessary.
6) Energize platform.
7) Remove gimbal clamps.
8) Monitor and record platform static drift at the output of the gimbal pickoffs for a period of time as specified in test requirements.

b. Second method

This method is the same as the first method except that when directionally orienting the platfrom the dividing head shall be leveled to the horizontal plane in two directions and the platform also shall be similarly leveled.

c. Third method

1) Place the platform in a suitable sidereal or planetary test stand which automatically corrects for earth's rotation.

NOTE: This third method is a better method but the disadvantage is that the required test stand represents the expenditure of a considerable amount of money; therefore, not many laboratories are so equipped.

2) Another method of determining gimbal movement is by means of an auto-collimating optical system. This would entail three auto-collimators and a mirror precisely affixed to each gimbal. This is an accurate method but not always possible. Due to the variety of methods of auto-collimating a procedure for this method is not included.

6.2.8.2 Dynamic Drift

Either method one or two outlined in paragraph 6.2.8.1 under static drift shall be used, except that in this test the platform shall be placed on a Scorsby table or a 3-axis flight simulating table, where motions of at least plus and minus 7.5 degrees at six cycles per minute can be imparted to the platform through each axis (roll, pitch and yaw) simultaneously.

6.2.9 Resolver Alignment

The resolver primary coils generally (but not always) are connected to the yaw and roll gyros. For presenting a test method, assume that the yaw and roll gyros are so connected. The test philosophy would be the same in any case.

a. Set up the platform as outlined in paragraph 6.2.8.1.

b. Connect a 3- channel recorder to the resolver such that the input to each of the two primary coils and the output of the secondary coil will be recorded.

c. Start the Scorsby table and the recorder and record for a period of time as specified in test requirements.

6.2.10 Gimbal Pickoff Alignment and Linearity

NOTE: It will be found that some platforms will have only two accelerometers but, in such cases, the procedures outlined above are still valid. The differences involved would entail the re-orientation of the platform by 90 degrees by means of a dividing head.

6.2.10.1 Preparation

a. Should there exist a closed servo loop between the accelerometers and gyro torques, this loop shall be opened on all accelerometers.

b. Mount the platform in its test fixture and level the platform on a dividing head.

c. From the designers drawings, determine the orientation of the pitch accelerometer to the zero output of the pitch gimbal pickoff.

d. Clamp the roll and yaw gimbals to the platform case with the special gimbal clamping device.

e. Connect the output of the pitch gimbal pickoff and the pitch accelerometer to the 3-channel recorder.

6.2.10.2 Test Conduct

a. Pitch gimbal pickoff alignment

1) Using the designer's drawing as a guide, tilt the pitch gimbal to the correct angle required to position the gimbal pickoff to zero output.

NOTE: The correct angle shall be determined by reading the accelerometer output. The angle ϕ required is:

$$\phi = \sin^{-1} {}^{E_o}/K \pm (\epsilon\sigma)$$

Where:

E_n = Accelerometer null offset in volts
E_o = Accelerometer output voltage
K = Accelerometer scale factor in volts per g
$(\epsilon\sigma)$ = Vector sum of all applicable misalignment errors including E_n
ϕ = Angular displacement of the accelerometer sensitive axis from the horizontal.

NOTE: For example, assume that k = 1 volt per g and $(\epsilon\sigma)$ = zero. Further, assume that the designer's drawing discloses that the pitch accelerometer is positioned 12 degrees in the positive acceleration direction when the platform is level and the platform pitch gimbal pickoff is at zero output. Since the angle between the accelerometer sensitive axis and the horizontal level is required to be 12 degrees, it follows that the accelerometer will detect an acceleration of g sin ϕ or g sin 12 degrees. Transposing equation 1, $E_o = k \sin \phi \pm (\epsilon\sigma)$. Using the values assigned above E_o equals $\sin^o\phi$ or E_o equals 0.20791 volts. The pitch gimbal now is tilted until $E_o = {}^o0.20791$ volts. The gimbal pickoff now shall be zero plus or minus the specified tolerances of alignment.

2) Record the correct angle and the gimbal pickoff.

b. Pitch gimbal pickoff linearity

1) Displace the gimbal no less than ten equally spaced intervals on each side of the pickoff center or null position.

NOTE: The term interval refers to check points for taking linearity readings (angular displacement in degrees versus pickoff output) For instance, if the gimbal had 60 degrees freedom in the positive direction and 20 degrees in the negative an interval would be 60/10 = 6 degrees and 20/10 = 2 degrees, respectively.

The correct pitch gimbal positioning can be determined for each interval can be determined by reading the accelerometer output and using the equation in the note in paragraph 6.2.10.2.

2) Record the angular displacement of the gimbal and the pickoff readout at each interval.

c. Roll gimbal pickoff alignment

Follow the same procedure as outlined in paragraph a., except that in this case, the roll accelerometer and roll gimbal pickoff are applicable.

d. Roll gimbal pickoff linearity

Follow the same procedure as outlined in paragraph b., except that in this case, the roll accelerometer and platform gimbal are applicable.

e. Yaw gimbal

Both the gimbal alignment and the pickoff linearity tests are to be conducted as described in paragraphs a and b except that in this case the yaw accelerometer and platform gimbalare applicable.

6.2.11 Gimbal Angular Freedom

a. Using a test setup as described in paragraph 6.2.10, displace the gimbal on each side of the pickoff center or null position until limit stops are reached.

b. Record the two accelerometer outputs.

6.2.12 Positioning of Azimuth Gimbal

When the platform includes an azimuth signal generator, the type and complexity of arrangement is wide and varied. In general, the test shall be performed similarly to the gimbal pickoff tests, except that the system may have to be broadened to include a simple optical system consisting of an auto-collimator used in conjunction with a mirror attached to the yaw gimbal. The test setup must include some means of determining the exact angle the auto collimator is positioned in reference d. The index is generally specified in designers' specifications. The sensitive axis of one of the guidance accelerometers is sometimes specified as the reference index. The yaw gimbal will be positioned at angles specified in test requirements and the auto-collimator will be used to determine and record the error of gimbal alignment of that angle.

6.2.12.1 Torque and General Characteristics of Azimuth Positioning

Following, or during, tests outlined in paragraph 6.2.12, torque, scale factors and linearity characteristics of azimuth signal generator shall be determined by attaching an adequate torque meter to the signal generator rotor and the recorder to the output of the signal generator. The yaw gimbal shall be displaced by means of the signal generator and torque meter output and signal generator output per degree shall be recorded. In some cases, the design of the platform may provide electrical torque generating means; if so the data recorded will be torque generator current and output per degree of rotation.

6.2.13 Gyro Precession

a. Connect the recorder to the input to the torque coil and output of the gyro.

b. Initiate gyro precession by injecting an electrical current into the gyro torque coil.

c. Monitor and record the input current and gyro output.

6.2.14 Platform Caging Provisions

Like gyro precession, platform caging is another expression which may be misleading. Previously, the term "caging" always referred to locking the platform gimbals to each other and to the case so that platform rigidity was fixed and locked mechanically onto itself. This meaning holds true at the present for some platform designs. Caging or mechanical locking can be achieved in two ways, manually or electrically. When accomplished electrically, it is sometimes done by means of a switch which actuates a solenoid and sometimes by a switch with motor drive. With either type of mechanical locking, testing for effectiveness consists of testing for electrical current drawn, security of locking (backlash, end-play, and firmness), or the time necessary to accomplish positive locking and reliability of the system.

The second meaning of "caging" refers to the platform being entirely free and uncaged with respect to the former sense of the meaning. This second meaning is fast coming into use. It means that the platform is caged (direction supposedly not alterable) to a preset orientation with respect to either earth or space coordinates. In other words, due to the platform's own closed servo-loop system, it is caged or fixed, during flight, to the original preset orientation. Tests for caging effectiveness to this concept would, in some circumstances, become involved and tests covering all procedures are beyond the scope of this pamplet. In general, however, tests for caging are tests of the accelerometer, gyro, platform gimbal torque generator, and closed servo-loop systems and these data are or can be obtained during dynamic drift tests on the Scorsby table or 3-axis flight simulator. Whether to use a Scorsby table or the flight simulator will be dictated by the accuracies called out in the related design specification. Tests conducted using a 3-axis flight simulator are superior to the Scorsby tests with the advantage that roll, pitch, and yaw motions can be programmed for magnitude and frequency.

6.2.15 Environmental Testing

a. Environmental tests shall be conducted on all inertial components in accordance with applicable MTP's.

b. Subject the platform (de-energized) to each environment indicated in design specifications.

c. Following subjection to each environment,repeat the drift test paragraph 6.2.8 to determine whether the specimen has sustained damage as a result or the environment.

d. Repeat the static drift test paragraph 6.2.8.1 while it is energized and operating in the specified environments.

e. Conduct the following four tests on the specimen while it is energized and operating.

1) Linear acceleration
2) Radio noise
3) Vibration
4) High and low temperature

6.2.15.1 Linear Acceleration

a. Preparation

1) Mount the platform on a centrifuge so that the accelerating force vector will be through (parallel to) one of the gimbal axes (for example the pitch gimbal axis).
2) De-energize all gyros and perhaps the accelerometers depending upon the closed loop circuitry of the platform.

NOTE: Since the output signal from the pitch gyro, when processed, will provide current to the platform pitch gimbal torque motor to rotate the pitch gimbal, it shall be necessary to open this circuit and substitute a simulated gyro signal.

3) Open the pitch gimbal circuit and substitute a simulated gyro signal by means of an external signal generator or d-c supply, which ever is applicable.
4) Connect an ammeter to the signal source to measure the current of the substitute signal.
5) Energize the platform gimbal pickoffs and monitor the outputs.

b. Test Conduct

1) Using the torque motor, rotate the gimbal in each direction to its limit stops.
2) Record the torque current required and the pickoff output. If possible both of these values shall be continously recorded on a 2-channel recorder so that an instantaneous comparison might be had.
3) Start the centrifuge and bring the acceleration up to the value called out by military specifications.
4) Repeat steps 1 and 2.
5) If the value of torque changes or if the pickoff output does not repeat as in step 2 a, binding or striction is indicated. Reduce the acceleration of the centrifuge until the striction is cleared.
6) This is the acceleration through the pitch gimbal axis the platform will withstand. Record this acceleration.
7) Using the same reasoning repeat paragraphs a and paragraph b steps 1 through 6 with the platform so positioned on the centrifuge that the accelerating force vectors will be through the yaw and roll gimbal axis of the platform.
8) Observe and record deleterious effects of the platform being subjected to high g acceleration.
9) Repeat static and dynamic drift tests (paragraph 6.2.8.2) to determine if deformation of structure due to strain and shifting of the center of gravity has occurred.
10) Observe the gimbaling system in all respects to determine and record whether or not any striction, shifting, or binding occurs.

6.2.15.2 Vibration

Vibration testing shall be conducted as specified in MTP 5-2-507 Vibration Test Procedures. Take care to select an adequate holding fixture. It should be rugged and of sufficient tensile strength, carefully machined for alignment, and free from any resonances within the frequency range of investigation.

6.2.15.3 Radio Noise

Radio noise test are complex and beyond the scope of this MTP. Suffice it to say that the platform shall be energized and operating, preferably on a Scorsby table, and the tests shall be conducted in a screen room in accordance with MIL-I-6181.

6.2.15.4 High and Low Temperature

High and low temperature tests shall be conducted in accordance with MTPs 5-2-583 Low Temperature Tests and 5-2-594 High Temperature Tests, to determine and record if striction or any other abnormalties occur. Conduct a dynamic drift test on a Scornsby table placed within the temperature chamber to reveal any abnormal results. Compare results obtained to those obtained in the tests described in paragraph 6.2.8.2 and record any differences.

6.3 TEST DATA

6.3.1 Visual Examination

Record the following:

a. Compliance with configuration and workmanship requirements
b. State of preservation
c. Packaging
d. Identification markings

6.3.2 Resistance and Insulation

Record all resistance values, insulation and dielectric results.

6.3.3 Gimbal Alignment and Construction

a. Preparation

1) Record the dividing head angle of tilt to be used as a zero reference tilt angle
2) Record the position of the rotating surface to be used as a zero reference for the rotating surface.
3) Record any algebraic differences between the roll gyro output observed in step 17 and step 13 of paragraph 6.2.3 as an indication of non-orthogonality of the platform inner gimbal with respect to the roll or middle gimbal.
4) Record any output voltage of the pitch gyro in step 25 as an indication of misalignment between the outer gimbal and the platform case or frame.

6.3.4 Accelerometer Null Offset

Record the accelerometer outputs for the lowest readings.

6.3.5 Accelerometer Alignment

No data recording specified

6.3.6 Accelerometer Scale Factor

Record the accelerometer output and angle of tilt.

6.3.7 Erection and Alignment Loops

Data shall be recorded as specified in MTP 5-2-538.

6.3.8 Platform Drifts

Record platform drift at the output of the gimbal pickoffs for a specified period of time.

6.3.9 Resolver Alignment

Record the input ot each of the two primary coils and the output of the secondary coil.

6.3.10 Gimbal Pickoff Alignment and Linearity

a. Gimbal pickoff alignment
Record the gimbal pickoff output and the correct angle ϕ.

b. Gimbal pickoff linearity
Record the angular displacement of the gimbal and the pickoff readout at each interval.

6.3.11 Gimbal Angular Freedom

Record the two accelerometer outputs

6.3.12 Positioning of the Azimuth Gimbal

Record the error of gimbal alignment at each angle.

6.3.12.1 Torque and Generating Characteristics of Azimuth Positioning

Record the torque of the signal generator rotor and the signal generator output per degree.

NOTE: In some cases, the design of the platform may provide electrical torque generating means; if so the data recorded will include torque generator current and output per degree of rotation.

6.3.13 Gyro Precession

Record the input current and gyro output.

6.3.14 Platform Caging

No data recording specified

6.3.15 Environmental Testing

6.3.15.1 Linear Acceleration

a. Record the torque current required and the pickoff output.
b. Record the maximum acceleration through the pitch gimbal axis which the platform will withstand.
c. Record any deleterious effects of the platform being subjected to high g acceleration.
d. Record data as specified in paragraph 6.2.8.2.
e. Record whether or not any striction shifting, or binding occurs.

6.3.15.2 Vibration

Data shall be recorded as specified in MTP 5-2-507.

6.3.15.3 Radio Noise

Data shall be recorded as specified in MIL-I-6181.

6.3.15.4 High and Low Temperature

Data shall be recorded as specified in MTP's 5-2-594 and 5-2-583.

6.4 DATA REDUCTION AND PRESENTATION

Accurate, comprehensive, and appropriate data sheets, recordings etc., shall be kept for all tests. Recorder tapes shall be identified and marked to tell a story to test analyzer. A final test report shall be compiled including all data sheets, graphs, charts, and drawings. Conclusions and recommendations based on an analysis of valid findings shall be included in the report.

6.4.1 Visual Examination

No additional data reduction necessary.

6.4.2 Resistance and Insulation

Compare all resistance values and insulation and dielectric results to applicable military specifications and missile purchase descriptions (MPD's).

6.4.3 Gimbal Alignment and Construction

From this test, a quantity of data has been collected and certain characteristics have been established or shall be calculated namely:

a. Alignment of the gyros on the stable element which is the inner gimbal
b. Orthogonality between the inner and middle gimbals
c. Orthogonality between the outer gimbal and the platform frame or case

By algebraically reducing the three characteristics above, orthogonality between the middile and outer gimbal shall be established.

NOTE: Actual reduction of the above paragraph may have to await determination of the gyro scale factor (SF) and transfer function to be determined in a later test.

6.4.4 Accelerometer Null Offset

No data reduction necessary

6.4.5 Accelerometer Alignment

No data reduction necessary

6.4.6 Accelerometer Scale Factor

The input to the accelerometer in g's is a function of the sine of the angle through which the dividing head is tilted. The accelerometer scale factor can be easily computed as output versus input in g's.

6.4.7 Erection and Alignment Loops

Data reduction for this test is described in MTP 5-2-538.

6.4.8 Platform Drifts

From the data obtained in paragraph 6.2.8 the drift rate may be calculated using the gimbal pickoff scale factor to convert the voltage recorded to degrees. Depending on which method was used, it may or may not be necessary to apply any correction for the earth's rotation for any drifts indicated in one or two of the gimbal axis. In addition, drifts in all three axis require correction for any applicable misalginment errors revealed during the tests in paragraph 6.2.3

6.4.9 Resolver Alignment

The resolver output recorded on tape should be at all time equal to the instantaneous vector sum of the two inputs. The two primary windings of the resolver will be connected to two gyros the input axis of which are vectorially sensitive to

a common angular velocity. Each gyro will be sensitive to two of the missile axis and the degree to which each is sensitive will vary with the missile"s space orientation; hence the vector representation.

6.4.10 Gimbal Pickoff Alignment and Linearity

a. The gimbal pickoff outputs shall be zero plus or minus the specified tolerances for alignment .

b. Linearity characteristics shall be determined by comparing the angular displacements of the gimbal to the pickoff readout.

6.4.11 Gimbal Angular Freedom

Gimbal angular freedom shall be computed from the accelerometer outputs using the equation described in the note in paragraph 6.2.10.2 a.

6.4.12 Positioning of the Azimuth Gimbal

No additional data reduction

6.4.13.1 Torque and General Characteristics of Azimuth Positioning

Torque, scale factors, and linearity characteristics shall be determined plotting a curve of torque versus signal generator output per degree of rotation.

6.4.13 Gyro Precession

Proper precession shall be checked and proven. The phase relationship shall have to be designated by the applicable design specifications.

6.4.14 Platform Caging

No data reduction specified

6.4.15 Environmental Testing

Data reduction is specified in applicable MTP's and military specifications.

APPENDIX A

DESCRIPTION OF STABLE PLATFORM GUIDANCE SYSTEMS

In a missile system using purely inertial guidance, the stable platform assembly provides a stable reference in flight and can be stabilized to either a space or an earth reference. The stability of the platform is provided by the gyroscope, orthogonally mounted to sense angular movements in the roll, pitch, and yaw modes. The movements sensed are routed in the form of error signals to servo-system which acts to restore the platform to its original position. The high degree of sensitivity of the sensors and the fast response of the servo system enable the platform to correct errors so rapidly that the platform remains essentially fixed (space caged) in its original position. The stable platform, then, along with its accelerometers and other sensing organs, provides missile guidance commands.

Prior to the launching of an inertially guided missile, the stable platform is leveled, erected, and oriented with respect to earth or space coordinates which are dictated by the range and direction of the target. During this period (prelaunch), certain biases are adjusted into the stabilization servo system. These biases are compensations for such forces as coriolis, inherent platform drift, platform component misalignment errors, etc. If these errors were not compensated, they would reflect proportionally as impact errors. It is not unusual for platform alignment accuracies of high order inertial systems to be held in the region of 0.2 mils. Platform drift errors and error measurements in certain other cirtical areas require input and output monitoring accuracies on the order of one part in 25 x $(10)^3$. The requirements for input frequency accuracy also are on the order of 0.01 percent regulation.